

DETERMINING ECONOMIC POTENTIAL OF FEEDSTUFFS WITH LINEAR PARAMETRIC PROGRAMMING TECHNIQUES

H. H. Taylor^{1,2}

ERS, USDA, Eastern Regional Research Center, 600
East Mermaid Lane, Philadelphia, Pennsylvania, 19118, USA

R. D. Taylor¹

Department of Agricultural Economics and Rural
Sociology, The Ohio State University, Columbus,
Ohio, 43210, USA

J. E. Cooper and W. F. Happich¹

ARS, USDA, Eastern Regional Research Center, 600
East Mermaid Lane, Philadelphia, Pennsylvania, 19118,
USA²

Summary

Linear Parametric Programming techniques (LPP) were utilized to determine the possible usefulness of products prepared in the laboratory from tannery unhairing effluent as substitutes for other ingredients in poultry rations at minimal costs within the assumptions, restrictions, prices, and bounds incorporated into the model. The products included (1) 91 Protein precipitated from tannery effluent, and (2) AA Sludge 90, an activated sludge grown on tannery effluent. Several price sensitivity analyses were made using LPP techniques, a computer satellite terminal, a computer utility and turn-key system, and nationally utilized nutritional data banks. The results of these analyses indicated that at this phase of technology assessment, these products have the potential to compete with other ingredients for use in poultry rations. The most feasible utilization of these products would probably include 2% or less of 91 Protein in layer and

broiler rations and 4% or less of AA Sludge 90 in a layer ration if these products could be commercially produced between \$17.64 and \$35.27 per 100 kilos.

These results indicate sufficient potential utility for these products, especially the AA Sludge 90, to justify controlled poultry feeding tests as the next step in the evaluation of these products. If the experimental feeding tests confirm these analyses, a commercially feasible production process and associated production costs would then be developed.

Key Words: linear cost ranging analysis, poultry rations, products derived from tannery unhairing effluent, and technology assessments.

Introduction

Effluent from leather tanning and finishing industries currently creates serious environmental problems. The Environmental Protection Agency (EPA) established guidelines to control effluent discharged into navigable waterways in the United States from tanneries (Federal Register 1974). The new standards for waste discharge for these industries will require substantial investment in effluent treatment facilities and produce large quantities of proteinaceous solid wastes which currently have no market value. Already some tanneries have closed because they could not economically meet local pollution standards.

Tannery unhairing effluents are complex mixtures of partially disintegrated hair, pieces of fat, particles of hide, lime, degraded solubilized proteins, sodium sulfide, and possibly some emulsified fat and sulfur (Happich et al., 1972).

¹Agricultural Economist, Economic Research Service, United States Department of Agriculture; Associate Professor; and Research Chemists, Agricultural Research Service, United States Department of Agriculture, respectively.

²Special acknowledgement should also be given to E. H. Bitcover and E. M. Filachione, Agricultural Research Service, Eastern Regional Research Center, USDA, for their work in connection with this project as well as to M. M. Taylor, also research chemist with ARS, for her work in analyzing the amino acid contents of the products.

Scientists of the Hides and Leather Laboratory of the Agricultural Research Service at the Eastern Regional Research Center have been investigating high protein products which can be prepared from tannery effluents in the course of treating these effluents. Two products have been produced in the laboratory for initial evaluations: a 91% protein material precipitated from tannery unhairing effluents (91 Protein), and acclimated activated sludge from biological treatment of tannery unhairing effluents (AA Sludge 90). Both products were analyzed to determine their elemental and amino acid compositions. They were both found to be high in protein nitrogen and free of potentially toxic levels of heavy metals. Each of these products was economically treated as a potential feed ingredient in least cost poultry rations through linear parametric price ranging analyses.

Justification of Study

Economic evaluation of a new product is necessary so that a total economic assessment can later be made. Through careful evaluation, both beneficial and undesirable results from long-ranged utilization of technological innovations can be properly assessed. The price sensitivity analyses of the new products for use as ingredients in poultry rations done in this study should be viewed as partial economic assessments in an early phase of overall evaluations.

In recent years, much research has been conducted to evaluate and utilize materials from effluents to not only reduce the problems associated with water pollution but also to derive products useful to mankind. For example, Cooper (1974), determined that a tannery processing an average 2500 hides per day would discharge about 3850 kg of BOD³ daily. This discharge is equivalent to a domestic population daily BOD discharge of approximately 71,400 people. Keratin from feather meal, hog hair, cattle hair or combinations of the above, when utilized at 5% or less in rations which were supplemented with other essential amino acids, resulted in normal weight gains in poultry (Summers et al., 1965; Moran et al., 1966; Moran et al., March 1967; Moran et al., May 1967; Moran and Summers, March 1968; Moran and Summers, May 1968; and Moran et al., 1969). Organic feed concentrate (OFC) developed from municipal sludge was fed to layers for 6 weeks and as the percent of OFC in the diet increased from 5 to 20%, egg production was either reduced or eliminated (Weinberg et al., 1971). Toxic minerals found in OFC was believed to be the cause (Sheffner et al., 1974); however, losses of calcium and essential amino acids were not replaced and this could also account for the loss of egg production.

³BOD can be defined as a measure of the biodegradable organic compounds in waste streams.

One of the major deficiencies of the above-mentioned studies in evaluating the economic potential of feedstuffs results when a certain percentage of the new product is used as a replacement for another ingredient based on one major factor-weight. In general, the experimental diets are deficient in many essential amino acids and other nutritional requirements. Taylor et al., (1968) utilized linear parametric programming (LPP) techniques to evaluate alternative forms of dehydrated alfalfa meal as substitutes for other feed ingredients in least cost feed diets.

The advantage of using LPP procedures permits either a coefficient of an ingredient, a ration requirement or the price of a potential new ingredient to vary while holding all other factors constant within the requirements, restrictions, and bounds placed upon the model. Points of substitution, at minimal cost, for different levels of the variable are then obtained. In addition, this procedure can indicate the required selling prices of the new ingredient at different levels of usage if it is going to compete with other ingredients for inclusion in the ration.

Procedure

Products 91 Protein and AA Sludge 90 were analyzed for use in poultry feeds through the aid of a satellite computer terminal using LPP price sensitivity techniques and nutritional data banks for poultry and swine supplied by Maddy Associates, Incorporated, through the services of Com-Share Computer Utility Company and a turn-key system.⁴ A separate computer evaluation was done for each of the two products. Prices were obtained from either Feedstuffs, Chemical Marketing Reporter, and/or Nutrition Service Association, Belleville, Illinois⁵. A layer phase II average summer ration was selected from the egg production program data bank (EPP) and a layer ration and a broiler finisher ration were selected from the poultry and swine program data bank (PSP) for use in evaluating the economic utility of the products.

For each product, a least cost computer solution was first obtained without the utilization of the new product. The potential value of each product in the selected ration was then determined by parametric cost ranging to obtain intrinsic value curves. Prices, ration requirements, and bounds on ingredients were held constant while the price

⁴Mention of specific suppliers of services does not imply endorsement by USDA over others not stated.

⁵Generally, prices for feed grains were quoted at Chicago from Feedstuffs, August 25, 1975. Prices for other ingredients as well as chemicals were either obtained from Feedstuffs, Chemical Marketing Reporter, or Nutrition Service Association for approximately the same time period and are considered to be average prices quoted from various locations in the United States.

of the new product was allowed to vary from \$2,204.60 to \$11.02 per 100 kilos. Points of substitution were obtained as the price of the new ingredient decreased and nutritional factors in the new product were substituted for nutritional factors from some other source. At each point of substitution a complete poultry ration could be obtained which would conform with the restriction, ration requirements, and bounds incorporated in the model. Changes in any of the coefficients, prices, constraints, and bounds would possibly result in different points of substitutions and intrinsic value curves.

Analysis

Nutrient contents of each of the new products are listed in Table 1. The coefficients for AA Sludge 90 were derived on 90% dry matter basis. Coefficients for the 91 Protein product were derived for about 95% dry matter basis. The nutrient requirements of the three rations are listed in Table 2. Table 3 lists the upper and lower bounds

TABLE 1 Nutrient Contents of 91 Protein and AA Sludge 90

| Item | Units | Products | |
|-------------------------|---------|-------------------------|---------------------------|
| | | 91 Protein ^a | AA Sludge 90 ^b |
| Metabolizable energy | kcal/kg | 2377. | 2780. |
| Protein | % | 91. | 26.55 |
| Total Fat | " | 1.2 | 1.8 |
| Calcium | " | .2 | 15.03 |
| Phosphorus, total | " | | .8 |
| Phosphorus, available | " | | .77 |
| Glycine plus serine | " | 8.95 | .85 |
| Sodium | " | | .75 |
| Chloride | " | | .75 |
| Sulfur | " | 4.57 | .99 |
| Arginine | " | 8.85 | 2.16 |
| Methionine | " | .47 | .27 |
| Methionine plus cystine | " | 8.67 | 1.17 |
| Lysine | " | 2.97 | .9 |
| Tryptophan | " | .43 | 1.08 |

^aCoefficients were derived from an average of three lots.

^bDue to variability, coefficients were derived from the lowest value of each lot.

placed on those activities which level of usage in a diet, if used, would be restricted as specified. Prices utilized in the model are as listed in Table 4.

Each product will be discussed independently and will include the EPP average layer ration, and the PSP broiler and layer rations. Each figure by-product will include three curves representing the points of substitution for alternative prices and level of usage of product in each ration. Tables 5 and 6 will include selected diets and

the percentage of each ingredient included in each diet of the three rations as well as the cost per 100 kilos and per metric ton. Columns 1, 6, and 10 of Table 5, and columns 1, 6, and 9 of Table 6 include the basic solutions and ingredients for EPP layer ration, PSP broiler ration, and PSP layer ration when the new products were not included.

91 Protein Product

In the EPP layer ration a total of 16 diets were obtained. The amount of 91 Protein included in the ration varied from .2 to 43.6% as the price for this product decreased from \$36.16 to \$11.02 per 100 kilos, Figure 1. The cost of the ration per 100 kilos changed from \$12.43 to \$3.24. A more realistic level of 91 Protein in the diet might be 2.2% at a cost of \$19.81 per 100 kilos and a diet cost of \$12.39. Poultry rations containing 5% or less of keratin from cattle hair supplemented with other essential amino acids resulted in normal weight gains in poultry. Based upon this research, and assuming production costs of 91 Protein, when established, do not exceed product acceptance level prices as determined by the computer evaluation, utilization of 2.2% of 91 Protein in an EPP layer ration could possibly be a realistic projection.

FIGURE 1 Calculated value of 91 protein in poultry diets at various levels of substitution.

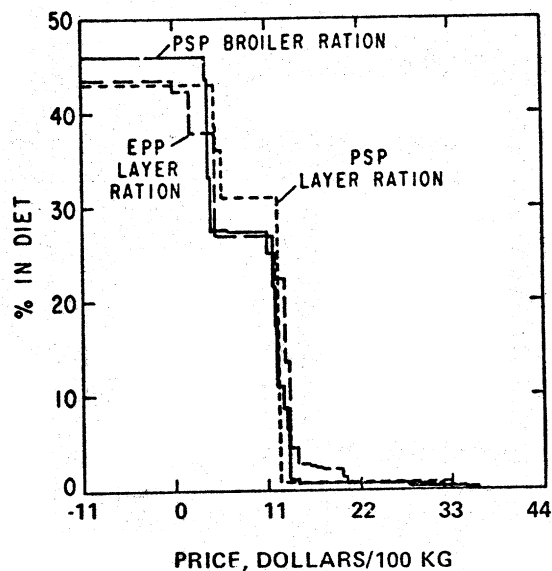


Table 5, columns 2 to 5, include four selected diets using 91 Protein which contain .2 to 25.2% of the product at prices from \$36.16 to 12.15, respectively. As the percent of 91 Protein was increased the level of usage of many ingredients changed. Feather meal and corn gluten feed were replaced. When 2.2% of 91 Protein was used, .4% cane molasses was added and when 25.2% of the product was included, 1.1% of fishmeal was added to that diet. Cost of the EPP layer ration decreased from \$12.43 to

TABLE 2 Nutrient Requirements of the Rations

| Item | Unit | Requirements ^a | | | | | |
|-----------------------|---------|---------------------------|----------------------|---------|----------------------|----------|----------------------|
| | | Egg production | | Poultry | | Broiler | |
| | | layer phase II | | layer | | finisher | |
| | | average summer | | level | | level | |
| | | Minimum | Maximum ^b | Minimum | Maximum ^b | Minimum | Maximum ^b |
| Metabolizable energy | kcal/kg | 2866. | 2866. | 2866. | 2866. | 3197. | 3197. |
| Protein | Percent | 16.85 | b | .00 | b | 19.90- | b |
| Fiber | " | .00- | 5.0 | .00- | 5. | .00- | 4. |
| Fat, total | " | .00- | b | .00- | b | .00- | b |
| Fat, added | " | 1.00- | 7.5 | .00- | 7.5 | .00- | 7.5 |
| Linoleic acid | " | 1.00- | b | .00- | b | .00- | b |
| Calcium | " | 3.56- | 3.76 | 3.50- | 3.7 | .80- | 1. |
| Phosphorus, available | " | .51- | .61 | .55- | .65 | .45- | .65 |
| Sodium | " | .14- | .24 | .15- | b | .15- | b |
| Chloride | " | .15- | b | .15- | b | .15- | b |
| Sulfur | " | .00- | b | .00- | b | .00- | b |
| Xanthophyll | " | 7.43 | b | .72 | b | 19.84 | b |
| Choline | " | .00- | b | .00- | b | .00- | b |
| Arginine | " | .84- | b | .97- | b | 1.00- | b |
| Methionine | " | .34- | b | .39- | b | .40- | b |
| Methionine + cystine | " | .61- | b | .70- | b | .70- | b |
| Lysine | " | .67- | b | .77- | b | 1.00- | b |
| Tryptophan | " | .17- | b | .19- | b | .20- | b |
| Glycine + serine | " | | | .00 | b | .00- | b |

^aRation restriction equations are in the form of either minimum, maximum, or equalities.

^bThe upper range for each requirement, if not specified, will be determined by the computer.

\$11.93 per 100 kilos or from \$124.48 to \$119.27 per metric ton, Table 5, columns 1 to 5.

Using the PSP broiler ration, 21 diets were obtained as the percent of 91 Protein varied from .3 to 46.2% and its price decreased from \$35.01 to 11.02 per 100 kilos, Figure 1. The cost of the ration decreased from \$13.03 to \$3.34; however, a realistic level of usage might be .6% of product 91 Protein at a cost of \$19.40 per 100 kilos and a diet cost of \$12.68. Table 5, columns 7 to 9 include three diets using .3 to 27.2% of 91 Protein as its price decreased from \$35.03 to 12.13, respectively. The cost of the ration decreased from \$13.03 to \$12.68 per 100 kilos or from \$130.34 to \$126.75 per metric ton. Soybean meal, calcium carbonate, fishmeal, corn gluten meal, and poultry by-products were replaced when 27.2% of 91 Protein was included. Animal fat was added as the percent of 91 Protein increased.

The PSP layer ration included six diets, Figure 1. The percentage of 91 Protein increased from .7 to 43.4% as

its price decreased from \$32.94 to \$11.02 per 100 kilos. The cost of the ration varied from \$12.28 to \$2.84 per 100 kilos. In Table 5, columns 11 and 12 include two diets using .7 and 31.3% of 91 Protein as its price decreased from \$32.94 to \$12.43 and the cost of the ration changed from \$12.28 to \$12.15 per 100 kilos or \$122.88 to \$121.52 per metric ton. Soybean meal was replaced when 31.3% of the product was used, Table 5, column 12.

AA Sludge 90

Figure 2 contains the points of substitution for each of the three rations using various levels of AA Sludge 90 at alternative prices. The EPP layer ration utilized from 1.2 to 16.5% of AA Sludge 90 as the price of the product decreased from \$20.55 to \$11.02. Eighteen points of substitution were included. The cost of the layer ration decreased from \$12.43 to \$8.55 per 100 kilos. The PSP broiler ration utilizing AA Sludge 90 at various levels obtained five points of substitution and

TABLE 3 Upper and Lower Bounds Placed on Those Activities Which Level of Usage in a Ration, if Used, were Restricted as Specified

| Ingredient | International feed number | Egg production Layer phase II | | Poultry Layer Lower % | Upper % | Broiler finisher | |
|--|---------------------------|-------------------------------|---------|-----------------------|---------|------------------|---------|
| | | Lower % | Upper % | | | Lower % | Upper % |
| Sorghum, milo, grain | 4-04-444 | .00 | 75.00 | .00 | 50.00 | .00 | 50.00 |
| Barley, grain | 4-00-549 | .00 | 20.00 | .00 | 20.00 | .00 | 20.00 |
| Wheat, grain | 4-05-211 | .00 | 20.00 | .00 | 20.00 | .00 | 20.00 |
| Sugarcane, molasses, more than 46% invert sugars more than 79.5 degrees brix | 4-04-696 | .00 | 3.00 | .00 | 3.00 | .00 | 3.00 |
| Alfalfa, aerial part, dehy, ground, 15 to 17% protein | 1-00-023 | .00 | 7.50 | .00 | 7.50 | .00 | 7.50 |
| Alfalfa, aerial part, dehy, ground, 17 to 20% protein | 1-00-024 | .00 | 7.50 | .00 | 7.50 | .00 | 7.50 |
| Cereal, distillers, grains with solubles, dehy | 5-02-146 | .00 | 5.00 | .00 | 100.00 | .00 | 100.00 |
| Animal, carcass residue, dry rendered ground, 55% protein | 5-09-323 | .00 | 5.00 | .00 | 5.00 | .00 | 5.00 |
| Animal, carcass residue with bone, dry rendered ground, 50% protein. | 5-00-388 | .00 | 5.00 | .00 | 5.00 | .00 | 5.00 |
| Poultry, feathers, hydrolyzed, dehy ground | 5-03-795 | .00 | 2.50 | .00 | 2.50 | .00 | 2.50 |
| Poultry, by-products, rendered dehy ground | 5-03-798 | .00 | 5.00 | .00 | 5.00 | .00 | 5.00 |
| Limestone, grounds | 6-02-632 | 2.50 | 2.50 | .00 | 100.00 | .00 | 100.00 |
| Salt, NaCl | 6-04-152 | .00 | .40 | .00 | .40 | .00 | .40 |
| Cotton, seed without oil, mech extd, 41% protein | 5-01-617 | | | .00 | 5.00 | .00 | 100.00 |
| Fish, herring, whole or cuttings, boiled mech extd, 41% protein | 5-02-000 | | | .00 | 10.00 | .00 | 10.00 |
| Fish, menhaden, whole or cuttings, boiled mech extd ground | 5-02-009 | | | .00 | 10.00 | .00 | 10.00 |
| Fish, anchovy, whole or cuttings, boiled mech extd ground (Peruvian) | 5-01-985 | | | .00 | 10.00 | .00 | 10.00 |
| Maize, gluten, wet milled dehy, 60% protein | 5-09-318 | | | .00 | 20.00 | .00 | 20.00 |
| Maize, gluten with bran, wet milled dehy (Gluten feed) | 5-02-903 | | | .00 | 30.00 | .00 | 30.00 |
| Maize, steepwater solubles, fermented condensed | 4-02-890 | | | .00 | 7.50 | .00 | 7.50 |
| Premix-layer | | .50 | .50 | .00 | 100.0 | .00 | 100.00 |

the percent of AA Sludge 90 varied from .3 to 2.5 as its price decreased from \$18.98 to \$11.02, Figure 2, Price 100 kilos of the broiler ration varied from \$13.03 to \$12.39. The use of PSP layer ration incorporating AA Sludge 90 yielded 16 points of substitution with AA Sludge 90 varying from .2 to 21.8% and its price from \$32.65 to \$11.02, Figure 2. The price of the ration per kilo varied from \$12.28 to \$6.72.

Table 6, columns 2 to 5, 7 and 8, and 10 to 12 represent the selected diets for EPP layer ration, PSP broiler ration, and PSP layer ration, respectively. In the EPP layer ration 1.2 to 15.2% of AA Sludge 90 were utilized as its price decreased from \$20.55 to \$6.17, respectively. The price of the ration decreased from

\$12.43 to \$11.33 per kilo or from \$124.28 to \$113.22 per metric ton, Table 6. The percent of yellow corn was reduced. Soybean meal 49%, oyster shells, and defluorinated phosphate 18% were eliminated from the ration and poultry by-products were added. At the 15.2% level of AA Sludge 90 usage cane molasses, wheat middlings, and calcium phosphate dibasic were required.

Use of AA Sludge 90 in the PSP broiler ration resulted in only minor adjustments from the basic solution as can be seen by evaluating Table 6, columns 7 and 8. The percent of AA Sludge 90 increased from .3 to 1.7 as the price decreased from \$18.98 to \$15.41. The price of the ration changed from \$130.34 to \$130.23 per

TABLE 4 Prices of Feed Ingredients^a

| Ingredient | International feed number | (Per 100 kg) |
|---|------------------------------|--------------|
| Maize, dent yellow | 4-02-935 | 11.03 |
| Sorghum, milo, grain | 4-04-444 | 11.24 |
| Barley, grain | 4-00-549 | 14.11 |
| Wheat, grain | 4-05-211 | 15.44 |
| Oats, grain | 4-03-309 | 21.28 |
| Sugarcane, molasses, more than 46% invert sugars more than 79.5 degrees brix | 4-04-696 | 6.62 |
| Wheat, bran, dry milled | 4-05-190 | 10.03 |
| Wheat, flour by-product, less than 7% fiber (Middlings) | 4-05-201 | 10.03 |
| Alfalfa, aerial part, dehy ground, 15 to 17% protein | 1-00-023 | 9.81 |
| Soybean, seeds without oil, solv extd ground, 44% protein | 5-20-637 | 16.16 |
| Soybean, seeds without oil without hulls, solv extd ground, 49% protein | 5-20-638 | 17.42 |
| Fish, menhaden, whole or cuttings, boiled mech extd ground | 5-02-009 | 26.46 |
| Fish, Anchovy, whole or cuttings, boiled mech extd ground (Peruvian) | 5-01-985 | 27.01 |
| Maize, gluten, wet milled dehy, 41% protein | 5-20-411 | 15.99 |
| Maize, gluten, wet milled dehy, 60% protein | 5-09-318 | 24.92 |
| Maize, gluten with bran, wet milled dehy | 5-02-903 | 10.14 |
| Cereals, distillers grains with solubles, dehy | 5-02-146 | 9.92 |
| Animal, carcass residue with bone, dry rendered ground, 50% protein | 5-00-388 | 18.48 |
| Poultry, feathers, hydrolyzed dehy ground | 5-03-795 | 19.03 |
| Poultry, by-products, rendered dehy ground | 5-03-798 | 20.13 |
| Animal, fat, dry rendered | 4-00-375 | 34.18 |
| Cotton, seeds without oil, mech extd ground, 41% protein | 5-01-617 | 14.33 |
| Sodium, sulfate, decahydrate, $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$ | 6-04-291 | 5.18 |
| Cattle, milk, skimmed dehy | 5-01-175 | 92.61 |
| Cattle, whey, dehy | 4-01-182 | 13.23 |
| Limestone, ground (Calcium carbonate) | 6-02-632 | 2.76 |
| Oysters, shells, fine ground | 6-03-481 | 4.96 |
| Rock, phosphate, defluorinated ground | 6-01-780 | 8.00 |
| Calcium, phosphate, dibasic (18.5%) $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ | 6-01-080 | 9.61 |
| Salt, NaCl | 6-04-152 | 2.98 |
| Choline Cl 5% (dry) | | 6.97 |
| MHA (Methionine hydroxy analogue) | | 207.27 |
| L-lysine HCL 98% | | 242.55 |
| Premix, layer | | 121.28 |

^aGenerally, prices for feed grains were quoted at Chicago from Feedstuffs, August 25, 1975. Prices for other ingredients as well as chemicals were either obtained from Feedstuffs, Chemical Marketing Reporter, or Nutrition Service Association for approximately the same time period and are considered to be average prices quoted from various locations in the United States.

metric ton but due to rounding does not show any change per 100 kilos from \$13.03.

Three diets using PSP layer ration and AA Sludge 90 are listed in Table 6, columns 10 to 12. The percent of AA Sludge 90 varied from .2 to .20.7 while its price

decreased from \$32.65 to \$10.78, respectively. The price per 100 kilos decreased from \$12.28 to \$11.46 or from \$122.88 to \$114.65 per metric ton. Substitution among ingredients resulted in the level of yellow corn, soybean meal 49%, animal fat, calcium carbonate, defluorinated phosphate 18%, and salt being reduced while soybean

TABLE 5 Selected Least Cost Diets Using Product 91 Protein in Three Different Rations

| Ingredients | Internal- tional Feed Number | Egg production program | | Poultry program | | | | | | | | | |
|---|---------------------------------------|--------------------------------|--------|--------------------------------|--------|--------|--------|--------|--------------------------------|--------|--------|--------|--------|
| | | Average summer layer | | Broiler ^a | | | | | Layer ^a | | | | |
| | | Price per 100 kg of 91 Protein | | Price per 100 kg of 91 Protein | | | | | Price per 100 kg of 91 Protein | | | | |
| | | 2205. | 36.16 | 19.91 | 14.57 | 12.15 | 2205. | 35.03 | 19.40 | 12.13 | 2205. | 32.94 | 12.43 |
| Percent in diets ^b | | | | | | | | | | | | | |
| Maize, dent yellow, grain | 4-02-935 | 64.2 | 64.2 | 64.5 | 65.0 | 62.2 | 70.1 | 70.1 | 71.7 | 52.1 | 60.2 | 60.0 | 45.2 |
| Alfalfa, aerial part, dehy ground 15 to 17% protein | 1-00-023 | | | | 2.5 | | 1.3 | 1.3 | 1.6 | 3.9 | | | |
| Soybean, seeds without oil, solv extd ground, 44% prot. | 5-20-637 | 9.9 | 11.0 | 16.3 | | | .1 | .1 | .2 | | | | |
| Soybean, seeds without oil without hulls, solv | 5-20-638 | 5.8 | 4.7 | | 11.5 | | 4.7 | 4.4 | 4.4 | 19.4 | | 19.0 | |
| extd ground 49% protein | | | | | | | | | | | | | |
| Cereal, distillers grains with solubles, dehy | 5-02-146 | 5.0 | 5.0 | 5.0 | 5.0 | | | | | | | | |
| Poultry, feathers, hydrolyzed dehy ground | 5-03-795 | 2.0 | 1.8 | | | | | | | | | | |
| Animal, fat, dry rendered | 4-00-375 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | | | .1 | 6.5 | 3.0 | 3.0 | 6.2 |
| Limestone, ground (Calcium carbonate) | 6-02-632 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | | .1 | .2 | 7.0 | 7.0 | 7.0 | 6.7 |
| Oysters, shells, fine ground | 6-03-481 | 5.0 | 4.7 | 5.1 | 5.0 | 4.8 | | | | | | | |
| Rock, phosphate, defluorinated ground (18% protein) | 6-01-780 | 2.2 | 2.2 | 2.3 | 2.3 | 2.4 | | | | 2.1 | 2.5 | 2.5 | 2.8 |
| Salt, NaCl | 6-04-152 | .2 | .2 | .2 | .2 | .2 | | .2 | .2 | .2 | .2 | .2 | .2 |
| Methionine hydroxy analogue | | .1 | .1 | .1 | .1 | .1 | | .c | .c | .2 | .2 | .2 | .2 |
| Fish, menhaden, whole or cuttings, boiled mech | 5-02-009 | | | | | 1.1 | 8.2 | 8.3 | 10.0 | .3 | | | |
| extd ground | | | | | | | | | | | | | |
| Fish, anchovy, whole or cuttings, boiled mech | 5-01-985 | | | | | | 1.6 | 1.5 | 2.7 | | | | |
| extd ground (Peruvian) | | | | | | | | | | | | | |
| Maize, gluten, wet milled dehy, 60% protein | 5-09-318 | | | | | | 1.3 | 1.2 | .8 | | | | |
| Maize, steepwater solubles, fermented condensed | 4-02-890 | | | | | | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| Maize, gluten with bran, wet milled dehy (Gluten feed) | 5-02-903 | 1.8 | 1.6 | | | | | | | | | | |
| Premix layer | | .5 | .5 | .5 | .5 | .5 | | | | | | | |
| Sugarcane, molasses, more than 46% invert sugars, more than 79.5 degrees brix | 4-04-696 | | | .4 | | | | | | | | | |
| 91 Protein | | .0 | .2 | 2.2 | 4.4 | 25.2 | .0 | .3 | .8 | 27.2 | .0 | .7 | 31.3 |
| Cost per 100 kg | | 12.43 | 12.43 | 12.39 | 12.26 | 11.93 | 13.03 | 13.03 | 12.96 | 12.68 | 12.28 | 12.28 | 12.15 |
| Cost per metric ton | | 248.57 | 248.57 | 247.80 | 245.24 | 238.54 | 260.67 | 260.67 | 259.17 | 253.51 | 245.77 | 245.77 | 243.04 |

^aThe inclusion of a layer of broiler premix at .5% would increase the ration costs by about \$.60 per 100 kg.^bDue to rounding, percents may not add to 100.^cLess than .1% in diet.

TABLE 6 Selected Least Cost Diets Using Product AA Sludge 90 in Three Different Rations

| Ingredients | Internal- tional feed number | Egg production program | | Poultry program | | | | | | | | | |
|---|---------------------------------------|------------------------|--------|----------------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| | | Average summer layer | | Broiler ^a | | | | | | | | | |
| | | 2205. | 20.55 | 16.16 | 12.76 | 6.17 | 2205. | 18.98 | 15.41 | 2205. | 32.65 | 17.66 | 10.78 |
| Percent in diets ^b | | | | | | | | | | | | | |
| Maize, dent yellow, grain | 4-02-935 | 64.2 | 63.2 | 58.7 | 56.5 | 51.7 | 70.1 | 70.4 | 70.5 | 60.2 | 60.5 | 66.4 | 52.3 |
| 1-Alfalfa, aerial part, dehy ground, 15 to 17% protein (17%) | 1-00-023 | | | | | 1.3 | 1.5 | 1.5 | | | | | |
| Soybean, seeds without oil, solv extd ground | 5-20-637 | 9.9 | 3.8 | | 2.5 | 10.7 | | | | | | | 6.5 |
| Soybean, seeds without oil without hulls, solv extd ground, 49% protein | 5-20-638 | 5.8 | 8.6 | | | | 4.6 | 4.2 | 2.3 | 19.4 | 19.1 | 7.3 | 7.9 |
| Cereal, distillers grains with solubles, dehy | 5-02-146 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | | | | | | | |
| Poultry, feathers, hydrolyzed, dehy ground | 5-03-795 | 2.0 | 2.4 | 2.5 | 2.5 | 2.5 | | | | | | | |
| Animal, fat, dry rendered | 4-00-375 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | | | | 3.0 | 2.9 | | |
| Limestone, ground (Calcium carbonate) | 6-02-632 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | .1 | | | 7.0 | 7.0 | 5.6 | |
| Oysters, shells, fine ground | 6-03-481 | 5.0 | 4.1 | 1.0 | | | | | | | | | |
| Rock, phosphate, deluorinated ground (18%) | 6-01-780 | 2.2 | 2.1 | 1.5 | 1.6 | | .3 | .2 | .2 | .2 | .2 | .1 | .4 |
| Salt, NaCl | 6-04-152 | .2 | .2 | .1 | .1 | .1 | .3 | .2 | .2 | .2 | .2 | .2 | .2 |
| Methionine hydroxy analogue | | .1 | .1 | .1 | .1 | .1 | .1 | c | c | c | .2 | .2 | .2 |
| Fish, menhaden, whole or cuttings, boiled mech extd ground | 5-02-009 | | | | | | 8.2 | 7.5 | 4.8 | | | | |
| Fish, anchovy, whole or cuttings, boiled | 5-01-985 | | | | | | 1.6 | 2.4 | 5.4 | | | 2.9 | |
| Maize, gluten, wet milled dehy, 60% protein | 5-03-318 | | | | | | 1.3 | 1.0 | 1.0 | | | | |
| Maize, steepwater solubles, fermented condensed | 4-02-890 | | | | | | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 | 7.5 |
| Maize, gluten with bran wet milled dehy (Gluten feed) | 5-02-903 | 1.8 | 5.3 | 16.8 | 16.6 | 4.2 | | | | | | | |
| Premix layer | | .5 | .5 | .5 | .5 | .5 | | | | | | | |
| Sugarcane, molasses, more than 46% invert sugars | 4-04-696 | | | | | 3.0 | | | | | | 3.0 | |
| Poultry, by-products, rendered dehy ground | 5-03-798 | | 4.4 | .6 | | | 5.0 | 5.0 | 5.0 | | | 5.0 | |
| Wheat, flour by-product, less than 7% fiber (Middlings) | 4-05-201 | | | 4.3 | | | | | | | | | |
| Calcium, phosphate, dibasic, CaHPO ₄ ·2H ₂ O | 6-01-080 | | | 1.6 | | | | | | | | | |
| AA Sludge 90 | | .0 | 1.2 | 5.9 | 10.5 | 15.2 | .0 | .3 | 1.7 | .0 | .2 | 3.5 | 20.7 |
| Cost per 100 kg | | 12.43 | 12.43 | 12.37 | 12.10 | 11.33 | 13.03 | 13.03 | 13.03 | 12.28 | 12.28 | 12.02 | 11.46 |
| Cost per metric ton | | 124.28 | 124.28 | 123.70 | 121.12 | 113.22 | 130.34 | 130.34 | 130.34 | 122.88 | 120.16 | 114.65 | 122.88 |

^aThe inclusion of a layer of broiler premix at .5% would increase the ration costs by about \$.60 per 100 kg.^bDue to rounding, percents may not add to 100.^cLess than .1% in diet.

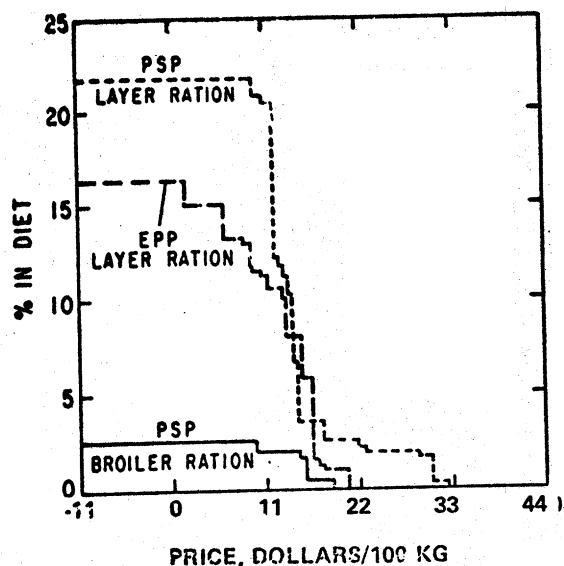


FIGURE 2 Calculated value of AA Sludge 90 in poultry diets of various levels of substitution.

meal 44%, fishmeal menhaden, cane molasses, and poultry by-products were added.

Conclusions

These products could economically compete with other ingredients in poultry diets provided that production costs, when established, do not exceed acceptance level prices and feeding tests confirm these analyses. Most feasible utilization of these products would possibly include 2% or less of 91 Protein in all rations, and 4% or less of AA Sludge 90 in PSP layer ration, assuming these products could be produced between \$17.64 and \$35.27 per 100 kilos.

Literature Cited

- Cooper, J. E. 1974. Biological treatment of industrial wastes. *The Leather Manufacturer*, 12.
- Federal Register. Tuesday, April 9, 1974. Environmental Protection Agency - leather tanning and finishing point source category. Washington, D. C. 39(69). 12958.
- Happich, W. F., M. L. Happich, J. E. Cooper, S. H. Fairheller, M. M. Taylor, D. G. Bailey, H. W. Jones, E. F. Mellon, and J. Naghski. 1974. Recovery of proteins from lime-sulfide effluents from unhairing cattlehides. *J. Am. Leather Chemists Assoc.* 69(2):50.
- Moran, E. T., Jr., J. D. Summers and S. J. Slinger. 1966. Keratin as a source of protein for the growing chick. 1. Amino acid imbalance as the cause for inferior performance of feather meal and the implication of disulfide bonding in raw feathers as the reason for poor digestibility. *Poul. Sci.* 45(6):1257.
- Moran, E. T., Jr., J. D. Summers and S. J. Slinger. 1967. Keratins as sources of protein for the growing chick. 2. Hog hair, a valuable source of protein with appropriate processing and amino acid balance. *Poul. Sci.* 46(2):456.
- Mon, E. T., Jr., H. S. Bayley and J. D. Summers. 1967. Keratins as sources of protein for the growing chick. *Poul. Sci.* 46(3):539.
- Moran, E. T., Jr. and J. D. Summers. 1968. Keratins as sources of protein for the growing chick. 4. Processing of tannery by-product cattle hair into a nutritionally available high protein meal: metabolizable energy, amino acid compositions and utilization in practical diets by the chick. *Poul. Sci.* 47(2):570.
- Moran, E. T., Jr. and J. D. Summers. 1968. Keratins as sources of protein for the growing chick. Practical application of feather and hog hair meal in broiler diets: effects on growth, feed utilization and carcass quality. *Poul. Sci.* 47(3):940.
- Moran E. T., Jr., W. F. Pepper and J. D. Summers. 1969. Processed feather and hog hair meals as sources of dietary protein for the laying hen with emphasis on their use in meeting maintenance needs. *Poul. Sci.* 48(4):1245.
- Sheffner, A. L., J. W. Keating, A. L. Palanker, M. S. Weinberg and R. Dean. 1974. Toxocological aspects in the nutritional evaluation of activated sludge. Foster D. Snell, Inc. and U.S.E.P.A., 14 pp.
- Summers, J. D., S. J. Slinger and G. C. Ashton. 1965. Evaluation of meat meal and feather meal for the growing chicken. *J. Anim. Sci.* 45:63.
- Weinberg, M. S., H. K. Weiss, A. L. Palanker and A. L. Sheffner. 1971. Sludge conditioning using SO_2 and low pressure for production of organic feed concentrate. Research Report No. 14-12-813, U.S.E.P.A., Cincinnati, Ohio. pp. 79 to 80, pp. 144 to 152.
- Taylor, R. D., G. O. Kohler, K. H. Maddy and R. V. Enochian. 1968. Alfalfa meal in poultry feeds - an economic evaluation using parametric linear programming. Agricultural Economic Report No. 130, ERS, USDA. 19 pp.